- to evaluate their implications for the present and future health of science;
- to provide continuing and comprehensive appraisal of U.S. science;
- to establish a new mechanism for guiding the Nation's science policy;
- to encourage quantification of the common dimensions of science policy, leading to improvements in research and development policysetting within Federal agencies and other organizations; and
- to stimulate social scientists' interest in the methodology of science indicators as well as their interest in this important area of public policy (NSB 1993b, xi).

Heyns clearly regarded the periodic preparation of the *Indicators* reports in terms of partnerships involving producers, users, and science policy scholars. The Board has called on all these groups over the years as it seeks to expand and refine these reports in order to reflect both the principal issues enduring in and changing science policy and the best scholarly thinking on quantification of these issues.[41]

In 1982, Congress officially recognized the unique significance of the *Indicators* reports by requiring that, instead of more broadly defined annual reports on the status and health of science required by the 1968 amendment to the National Science Foundation Act, "The Board shall render to the President, for submission to the Congress no later than January 15 of each even numbered year, a report on indicators of the state of science and engineering in the United States." [42]

This same legislation also encouraged submission of other reports on important science- and engineering-related issues, stating that "The Board shall render to the President for submission to the Congress reports on specific, individual policy matters related to science and engineering and education in science and engineering, as the Board, the President or the Congress determines the need for such reports."

Beginning with the 1987 edition, and consistent both with this legislation and the changing character of the U.S. research enterprise, the titles of these mandated biennial reports became *Science and Engineering Indicators*.

Presidential Statements

U.S. presidents from Franklin D. Roosevelt through William J. Clinton have demonstrated their recognition of the importance of science and engineering in a number of ways: through, for example, annual budget submissions to Congress, organizational initiatives designed to improve the effectiveness of the Federal Government's research and policy-making systems, and programmatic initiatives using science and engineering to advance critical items on their broad policy agenda. (See sidebar, "Major Presidential Science Policy Initiatives.") However, few presidents have given public addresses focused primarily on their science policies. The first notable exception was a speech delivered by President Truman in September 1948 during the first time of transition. Almost exactly 50 years later, in February 1998 during the current time of transition, President Clinton also delivered a public science policy address.[43] A comparison between these two speeches indicates both the endurance of several key science policy themes over the past half-century and the significant changes in emphasis that have occurred during that time.

Harry S Truman, 1948

President Truman delivered his address at the opening session of the Centennial Meeting of AAAS in Washington, D.C. (Truman 1948). A report of his speech was featured the next day on a front-page article in *The New York Times*. Truman used the occasion to propose a national science policy whose five principal elements were drawn directly from the report Steelman published a year earlier.

First, the President called for a doubling of total national R&D expenditures over the next 10 years so that, by 1958, those expenditures would exceed $2 billion and would be equal to 1 percent of GDP, or what he referred to as national income. The occasion of President Truman's AAAS address marked the first instance in which a leading political figure proposed that U.S. national R&D investments should be gauged in terms of GDP. As it happened, by 1958, national R&D investments had far exceeded the challenge that President Truman had laid down 10 years earlier. According to official estimates, in 1948, national R&D expenditures were slightly less than 0.5 percent of GDP; by 1958, that ratio was estimated to have been 2.36 percent. Changes in the Department of Defense's accounting system during the 1948–58 period make it difficult to compare R&D expenditures over that period.[44] But it is reasonable to assume that the R&D/GDP ratio, calculated according to the prevailing accounting practices of 1948, would have been closer to 2 than to 1 percent by 1958.

When President Truman spoke to AAAS, however, he could not have foreseen two of the principal reasons for the spectacular increases in national R&D expenditures that were to occur during the next decade: first, a rapid growth in defense R&D following the invasion of South Korea in June 1950; second, substantial increases for basic research and space-related R&D following the launching of Sputnik I by the Soviet Union in

[41]Papers presented at a symposium organized to critique the first, 1972 report were published in Elkana et al. (1978).

[42]Congressional Reports Act, Public Law 97-375, Section 214, enacted December 21, 1982.

[43]President Dwight D. Eisenhower announced the appointment of a full-time science advisor in a national radio address on November 7, 1957. President John F. Kennedy made a major science policy address at the Centennial celebration of NAS on October 23, 1963 (NAS 1963). President James E. Carter spoke at NAS on April 23, 1979, on the occasion of its annual meeting (*Weekly Compilation of Presidential Documents* 1979).

[44]Beginning in FY 1953, the Department of Defense began to include salaries and related expenses of personnel engaged in R&D in its estimates of R&D expenditures, resulting in an increase of approximately $1 billion in its estimated R&D expenditures between FY 1952 and FY 1953 (NSF 1968, 221, note c).

Major Presidential Science Policy Initiatives

♦ **Franklin D. Roosevelt (1933–45)** requested the first comprehensive survey and analysis of Federal science and technology resources and programs, entitled Research—A National Resource (1938). In 1941, he created the Office of Scientific Research and Development to mobilize the Nation's science and engineering resources for World War II, and in November 1944 asked for recommendations on how the lessons learned in mobilizing science for war could serve the Nation in peacetime.

♦ **Harry S Truman (1945–53)** worked with Congress to shape legislation creating three major agencies: the Atomic Energy Commission (1946), the Office of Naval Research (1946), and the National Science Foundation (1950). Truman also established the Science Advisory Committee to the White House Office of Defense Mobilization, the first presidential advisory system.

♦ **Dwight D. Eisenhower (1953–61)** established the President's Science Advisory Committee and appointed a full-time science advisor (1957). He oversaw the launching of the first U.S. satellites and proposed legislation to create the National Aeronautics and Space Administration (July 29, 1958). Eisenhower also worked with Congress to craft legislation—The National Defense Education Act (September 2, 1958)—which significantly increased U.S. Government support for science and engineering education at all levels.

♦ **John F. Kennedy (1961–63)** set the goal of sending a man to the moon by the end of the decade. He established the Office of Science and Technology within the Executive Office of the President in June 1962. He also proposed and oversaw implementation of a presidential-level bilateral science and technology agreement with Japan, the first such bilateral agreement entered into by the United States. Kennedy delivered a major science policy address at the National Academy of Sciences on October 23, 1963, as part of its 100th anniversary celebration.

♦ **Lyndon B. Johnson (1963–69)** emphasized science in service to society by making use of social science data as the basis for his War on Poverty and other components of his Great Society program. In inaugurating Medicare in June 1966, he noted that, as President, he had an obligation to show an interest in how the results of biomedical research are applied. Johnson also maintained U.S. leadership in space.

♦ **Richard M. Nixon (1969–74)** presided over the creation of high-level bodies charged with providing advice on science- and technology-related issues, including the Council on Environmental Quality within the Executive Office of the President (March 1970), the National Advisory Committee on Oceans and Atmosphere (August 1971), and the White House Energy Policy Office (June 1973). His War on Cancer initiative led to considerable increases in Federal funding for biomedical research. Nixon also realized a goal of a predecessor when Neil Armstrong walked on the moon in July 1969.

♦ **Gerald R. Ford (1974–77)** agreed with Congress that the presidential advisory system, abolished in 1973, should be reestablished, leading to a May 1976 Act creating the Office of Science and Technology Policy. His annual budget requests included increases in Federal expenditures for nondefense R&D, which had been declining in constant dollar terms since 1968.

♦ **James E. Carter (1977–81)** initiated Federal research programs aimed at developing renewable energy sources, including solar energy and fusion, and established programs to assist industry to demonstrate the feasibility of extracting oil from coal and oil shale. He signed the first bilateral science and technology agreement with the People's Republic of China in 1979.

♦ **Ronald W. Reagan (1981–89)** substantially increased defense R&D expenditures, particularly for his Strategic Defense Initiative, commonly called "Star Wars." He established modest programs within the National Bureau of Standards (now the National Institute for Standards and Technology) to provide research support to industry. Reagan also negotiated a significant expansion in the U.S.–Japan bilateral science and technology agreement, which included Japanese support for U.S. researchers to work in Japan.

♦ **George W. Bush (1989–93)** oversaw the development of the Federal Government's first technology policy, which was intended to augment and extend the established bipartisan consensus on science policy. He increased the size and scope of the National Institute for Standards and Technology's industrial research support programs. With Bush's encouragement, D. Allan Bromley, The Assistant for Science and Technology, emphasized strengthened international scientific interactions, initiating a biannual series of off-the-record meetings with his G-7 counterparts (known as the Carnegie Group meetings) and taking the lead in establishing the Megascience Forum within the Organisation for Economic Co-operation and Development.

♦ **William J. Clinton (1993–2001)** established links between science and technology policy and economic policy with his 1993 policy statement entitled Technology: The Engine of Economic Growth (Clinton and Gore 1993) and reaffirmed his commitment to university research and to science and mathematics education by endorsing them in Science in the National Interest (Clinton and Gore 1994). Clinton has been a strong advocate of improvements in science education and has expanded Federal support for information technologies substantially through long-term, coordinated interagency initiatives.

October 1957. Federal expenditures increased from $625 million in 1948 to $6.8 billion in 1958 ($5.4 billion in 1948 constant dollars). But Federal expenditures alone did not account for all the increase that occurred during the decade after President Truman's speech. During that same decade, industrial R&D investments rose from an estimated $450 million to approximately $3.7 billion in 1958, almost $3.0 billion in 1948 constant dollars (NSF 1998, 82–93, table B-6).

The *second* element of President Truman's proposed science policy was to place greater emphasis on basic research and medical research. Today, there exists a strong bipartisan consensus that both categories of research need to be adequately supported, even though they are rarely linked as explicitly as in President Truman's AAAS address.

The *third* element of President Truman's proposed science policy—that a National Science Foundation should be established—was, of course, accomplished 21 months later when, on May 10, 1950, he signed the National Science Foundation Act of 1950 into law.

The *fourth* element—that more aid should be granted to universities, for both student scholarships and research facilities—indicated recognition by the administration of the importance of universities to the national research enterprise. Concerns about the World War II human resources deficit discussed in both *Science—The Endless Frontier* and *Science and Public Policy* no doubt underlay President Truman's call for more scholarships. Today, concerns about human resources for science and engineering focus on the composition and distribution of highly trained personnel across disciplines and sectors, while the need to provide adequate facilities for university research remains a perenial issue.

As the *fifth* and final element of his proposed science policy, President Truman stressed the need for better coordination of the work of the Federal research agencies, reflecting the desire of BoB for assistance in maintaining better oversight of the burgeoning Federal R&D enterprise. That concern began to be addressed in April 1951 when President Truman established the SAC/ODM, a body that enjoyed some access to the President and that, in November 1957, was elevated into the PSAC by President Eisenhower.

Having enumerated these elements of his proposed science policy, the President devoted the remainder of his speech to some of the major national needs that U.S. science was being called upon to address, as well as the support that science required in order to address those needs. In 1948, Cold War tensions were rapidly escalating. Not surprisingly, then, the President focused sharply on the obligations of U.S. science to continue to support national security objectives. Significantly, he singled out what he called "pure—or fundamental—research" as an area of the highest importance to the country's long-term national defense requirements.

The President suggested that the Federal Government had two obligations in connection with the U.S. research system: first, to see that the system received adequate funds and facilities; second, to ensure that scientists were provided with working environments where research progress was possible. Regarding the second of these obligations, he stressed that, "pure research is arduous, demanding, and difficult. It requires intense concentration, possible only when all the faculties of the scientist are brought to bear on a problem, with no disturbances or distractions." He went on to urge that, to the greatest extent possible, the pursuit of research should be insulated from day-to-day political concerns.

Near the conclusion of his address, President Truman spoke about the need for greater public awareness of the importance of research to the Nation:

> The knowledge that we have now is but a fraction of the knowledge we must get, whether for peaceful use or for national defense. We must depend on intensive research to acquire the further knowledge we need … These are truths that every scientist knows. They are truths that the American people need to understand (Truman 1948, 14).

New knowledge requirements, he emphasized, must encompass all disciplines:

> The physical sciences offer us tangible goods; the biological sciences, tangible cures. The social sciences offer us better ways of organizing our lives. I have high hopes, as our knowledge in these fields increases, that the social sciences will enable us to escape from those habits and thoughts which have resulted in so much strife and tragedy (Truman 1948, 15).

"Now and in the years ahead," he concluded, "we need, more than anything else does, the honest and uncompromising common sense of science. When more of the peoples of the world have learned the ways of thought of the scientist, we shall have better reason to expect lasting peace and a fuller life for all."

William J. Clinton, 1998

On February 13, 1998, during the current time of transition, President Clinton addressed AAAS at its 150th anniversary meeting in Philadelphia (Clinton 1998). As might have been expected, President Clinton made explicit reference to his predecessor's speech as a means for highlighting the revolutionary changes that had occurred as a result of advances in science and engineering during the intervening half-century. That two of his references were to fields that did not even exist in President Truman's day—namely, space science and information technology—provides one measure of the scope of those changes.

President Clinton's speech touched on many of the issues that President Truman had raised 50 years earlier, although with strikingly different emphases. President Truman's first point was that total national R&D investments should be doubled, reflecting the *Science and Public Policy*'s contention that the overall level of those investments was inadequate to the broad needs of the Nation. By contrast, President Clinton was able to remind his audience that the FY 1999 budget proposal that he had recently submitted to Congress included substantial increases for most of the principal Federal research agencies.[45]

[45] *Budget of the United States Government for Fiscal Year 1999*, p. 93–104.

President Truman had linked basic research with medical research in urging that greater emphasis be given to both. President Clinton spoke more broadly about an expanded commitment to discovery. In noting advances that had occurred in health research, he reminded his audience that these advances had depended upon progress in a wide range of science and engineering fields.

Both presidents spoke about the conditions required for the conduct of high quality research. But where President Truman focused on insulating research from short-term political issues, President Clinton stressed the need for a long-term, stable funding environment.

Perhaps the most telling contrast between the two speeches was with the specific emphases placed on the national objectives that research should serve. President Truman spoke at length about science, engineering, and national security, which was appropriate in a year in which Cold War tensions were markedly increasing. However, the national security theme was entirely absent from President Clinton's speech. Rather, his emphasis was on the economy, the environment, and quality of life. President Clinton also spoke about social responsibility, noting that "it is incumbent upon both scientists and public servants to ensure that science serves humanity always, and never the other way around." As an example, he referred to ethical problems associated with advances in biotechnology, a reference that President Truman could not possibly have made, since the structure of the DNA molecule, a prerequisite for modern, molecular-based biotechnology, was not to be discovered until 1953.

A good deal of President Truman's speech had to do with the obligations of the Federal Government toward science; in contrast, President Clinton emphasized the need for strengthened partnerships between science and other national sectors.

Both presidents touched on the public understanding of science: President Truman stressing the need for Americans to understand the special needs of research; President Clinton, the need to increase public awareness of the promise of science for the future.

Both Presidents Truman and Clinton concluded their remarks by looking toward futures that appeared very different in 1948 and 1998. President Truman's optimism was guarded, reflecting the still fresh memories of World War II and the uncertainties inherent in the deepening Cold War. In contrast, President Clinton's concluding remarks, which linked advances in knowledge with fundamental American values, were buoyant:

> I believe in what you do. And I believe in the people who do it. Most important, I believe in the promise of America, in the idea that we must always marry our newest advances and knowledge with our oldest values, and that when we do that, it's worked pretty well. That is what we must bring to the new century (Clinton 1998, 10).

Current Visions/Key Policy Documents

Science in the National Interest (1994)

The concept of a National Science Foundation began to take shape in 1944, near the end of a period in which national defense had dominated the Nation's agenda. Only a handful of visionaries in science and government understood that a well-articulated policy would be required in order for the Nation to derive optimum peacetime benefits from science and engineering.

As the 1990s opened, the United States faced the novel challenge of redefining its goals and priorities in the post-Cold War era. By then, the importance of science and engineering to the United States had been firmly established. Indeed, they had assumed a significance that the visionaries of the 1940s probably could not have anticipated. Implementation of the recommendations of *Science—The Endless Frontier* and *Science and Public Policy*, which their authors had assumed would occur in a time of peace, actually took place during a period when national defense considerations once again dominated the national agenda. Thus, with the Cold War over, it was useful to rearticulate the importance of science and engineering to the Nation and redefine their roles in an era in which social and economic concerns were destined to increase in importance relative to national security concerns.

The organization of science and technology within the Federal Government also evolved during the Cold War era in response to changing political, economic, and social circumstances. In May 1976, the U.S. Congress, with the encouragement of President Gerald R. Ford, created the Office of Science and Technology Policy (OSTP) within the Executive Office of the President, in effect reconstituting the Office of Science and Technology (OST), which had been created by President John F. Kennedy in 1962 and abolished by President Richard M. Nixon in 1973. The National Science and Technology Policy, Organization and Priorities Act of 1976 also provided for an external presidential committee analogous to PSAC, which President Nixon abolished at the time he abolished OST. This provision was finally implemented in 1989 when D. Allan Bromley, the President's Assistant for Science and Technology, convinced President George Bush to establish the President's Council of Advisors on Science and Technology. In a coordinated action, Bromley reinvigorated the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), a body consisting of the heads of all U.S. Government agencies with significant science and technology responsibilities. In 1993, President Clinton expanded the membership of FCCSET to include the heads of appropriate agencies within the Executive Office of the President, renaming it the National Science and Technology Council (NSTC).

In 1994, 50 years after Senator Harley Kilgore (D-WV) introduced his first bill to create a National Science Foundation and President Roosevelt requested advice from Vannevar Bush on the organization of science in the post-World War II